## CERTIFICATION OF TRANSLATION

I, Jürgen D. Hengelhaupt, partner of **Gulde Hengelhaupt Ziebig & Schneider** of Wall strasse 58/59 D-10179 Berlin, hereby declare under penalty of perjury that I understand the German language and the English language; that I am fully capable of translating from German to English and vice versa; and that, to the best of my knowledge and belief, the statements in the English language in the attached translation of the priority document (European Patent Application No. 02 090 276.3), consisting of 16 pages, have the same meanings as the statements in the German language in the original document, a copy of which I have examined.

Signed this 29th day of March 2005.

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## Projection display on the basis of organic light-emitting diodes

### Description

The invention concerns a projection display on the basis of organic light-emitting diodes and a method for the projection of images and similar.

Projection displays are being increasingly applied in the entertainment electronic sector, such as for example in large format projection television sets.

A first generation of projection displays was realised with cathode ray tubes. The intermediate picture produced on a phosphor screen by means of electronic excitation was projected onto a screen through an optical unit. However, the required intensities for the applied picture tube technology are very demanding and put a limit on the life duration. In addition, the power input is high and the projection equipment unit is relatively heavy and large.

At present, projection displays are mainly applied on the basis of liquid crystals. The required light source in this case consists typically of a white light lamp whose light is modulated, with spatial resolution, by means of a liquid crystal (LCD) matrix. The required light colours are produced by means of absorbing colour filters. By means of colour mixing on the reflecting and transmitting screen, respectively, the enlarged image is established.

Furthermore, a method is known where an array of micro mirrors provides for the required modulation of the incident light. Again, colour filters are necessary for the production of the required colours.

Moreover, the use of self-emitting organic light-emitting diodes (OLED) as a light source for projection displays is known.

EP 0 838 715 A1 and EP 0 869 388 A1 describe projection displays which use organic light-emitting diodes as a light source. The required modulation of the light intensity is attained by means of an upstream-located liquid crystal matrix. The organic light-emitting diode in this case does not function as an active control element but only as a light source, similar to a back light in LCD-displays.

The disadvantage here is that optic losses resulting from polarisor and liquid crystal have to be compensated with a corresponding brightness of the organic light-emitting diodes.

The invention here is therefore based on the task assignment of stating and presenting a projection display which eliminates the disadvantages as mentioned above.

This task assignment is solved according to the invention by the features in the designating part of Claim 1 (device claim) and the Claim 15 (method claim) in conjunction with the features in the generic term. Purposeful embodiments of the invention are contained in the sub-claims.

A special advantage of the invention is the fact that the display elements on the basis of organic light-emitting diodes are utilised as active light control elements. For this purpose, the light-emitting diodes are operated in the so-called photo luminescence quenching mode. The function of the photo luminescence quenching mode is based on the effect that photo luminescence emission of an organic material can be suppressed by an applied electric field. In a first step, the emitter material is optically excitated by an external light source. Excitated conditions are established which, in the typical manner of a period of some nanoseconds, decay while emitting photo luminescence light at the same time. The emitted light in this case has a colour which is characteristic for the emitter material in each case. A further advantage here is that no colour filters are required for such a projection display.

By applying an additional voltage, an electric field can be produced in the emitter material. This field causes the partial split-up of the excitated conditions in charge carriers before photo luminescence radiation can be emitted. In this way, the concentration of excitated conditions is lowered and, as a consequence thereof, the intensity of the photo luminescence light is reduced. Therefore, there is subsequently the possibility for controlling the intensity of the photo luminescence radiation by the applied voltage. Without applied voltage, the intensity is at its maximum, whereas it is reduced under applied voltage.

A further advantage is that the control current, which must be made available by means of a suitable driver circuit, can be kept at a low level. The reason for this is the fact that the photo luminescence quenching mode has significant advantages with reference to the quantum efficiency. In this way and for each quenched excitation, only one charge carrier pair is generated which must flow off by way of the contacts. The light of an excitation light source is conducted to an array of organic light-emitting diodes and excitates the display elements of the array to emit photo luminescence light. With the use of a suitable driver circuit, a voltage can be applied to each organic light-emitting diode, leading there to photo luminescence quenching. The light emitted from the array can be projected through a projection optic unit onto a screen and/or a transparent diffusing screen.

The photo luminescence quenching mode in this case allows the attainment of adequate brightness with a low level of required current which flows through the display element.

The invention is explained in greater detail on the basis of embodiments shown at least partially in the figures.

The figures show the following:

Fig. 1: a schematic arrangement of a projection display in the photo luminescence quenching mode with reflecting cathode and front-side injection-coupling of the excitation light via the anode,

Fig. 2: a schematic arrangement of a projection display in the photo luminescence quenching mode with light-transparent cathode and front-side injection-coupling of the excitation light,

Fig. 3: a schematic arrangement of a projection display in the photo luminescence quenching mode with rear-side injection-coupling of the excitation light via the cathode,

Fig. 4: a schematic arrangement of a projection display in the photo luminescence quenching mode with rear-side injection-coupling of the excitation light via the anode.

Fig. 1 shows a preferred configuration for an OLED projection display in the photo luminescence quenching mode where the excitation light is injection-coupled at the front side of the OLED array. The excitation light is converted in the sub-pixels for red 6, green 7 and blue 8 in the form of photo luminescence light into the respective colour and again radiated. The emitted photo luminescence radiation is imaged on a screen through a projection optic unit 10. By applying a voltage between the transparent anode 2 and the reflective cathode 5, the radiated light volume can be controlled for each sub-pixel. A suitable driver circuit for the brightness control is a thin film transistor circuit which can be realised by means of polycrystalline or monocrystalline silicon, and is required once for each sub-pixel. An active driver matrix results from the interconnection. In addition, the device has a hole transport layer 3. For this hole transport layer 3, dispersions of poly(ethylene dioxy thiophene) / polystyrene sulfone acid and polyaniline can be used. For the emitter polymers, special polymers from the material classes of the polyphenylene vinylene and the polyfluorene can be given consideration.

Fig. 2 shows a second preferred embodiment. The excitation light is again injection-coupled on the emission side of the display. In this case, a non-transparent substrate can be applied because the injection-coupling and de-coupling of light is effected by means of a transparent contact.

In particular, monocrystalline silicon can be used as substrate material. The required driver electronics can therefore be directly integrated into the display element.
The advantage of this application lies in particular in the high driver currents which can be obtained as a result of the high charge carrier mobility in monocrystalline silicon. A high degree of obtainable brightness of the display accompanies this.

Fig. 3 shows a schematic arrangement of a projection display in the photo luminescence quenching mode with rear-side injection-coupling of the excitation light via the cathode. The light which is injection-coupled from the rear side passes a narrow band dielectric mirror which has high reflectivity with respect to the individual emission wavelength of the OLED. In the case of the red sub-pixel, red is therefore strongly reflected whereas the light coming from the lamp is allowed to pass through without hindrance.
Lamps with a high quota of blue and ultraviolet light are preferentially used. In this case, gas discharge lamps, such as mercury and xexon lamps are given consideration. The mirror layer can be established by means of the application of multi-layers with major variation in the refractive index, where the optic path length of a layer amounts to one quarter of the reflection wave length.
Suitable materials with a low refractive index are, for example, silicon dioxide, silicon nitride, magnesium fluoride and associated materials.
Suitable materials with a high refractive index are, for example, titanium dioxide, tin oxide, zirconium oxide and tantalic oxide. A transparent cathode layer follows on the dielectric mirror. Suitable material combinations are, for example, base metals such as calcium, magnesium, barium and aluminium which are deposited in a thin layer onto the emitter layer and, for the purpose of increasing the conductivity, are covered with a layer of conductive and transparent material such as indium tin oxide (ITO). As additional layers, metal fluorides such as lithium fluoride, barium fluoride or magnesium fluoride can be integrated between the emitter layer and the cathode metal. The thickness of the ITO-layer can be selected in such a way that it represents the first layer of the dielectric mirror.

Fig. 4 shows a schematic arrangement of a projection display in the photo luminescence quenching mode with rear-side injection-coupling of the excitation light via the anode. This is built up on a corresponding dielectric mirror.

Compared with Fig. 2, this symmetry has the advantage that the structurisation processes can be effected for the mirror and the anode contact on the substrate before organic layers are deposited which react sensitively to the process conditions of the structurisation. In addition, it is possible here to build up the dielectric mirror from conductive polymer materials. The emission of photo luminescence light is effected through the transparent cathode layer.

All shown structures can be extended by means of additional measures for the improvement of the injection-coupling and de-coupling of light. This includes, among other things, micro lenses on the inlet and outlet sides as well as reflection-reducing layers. In addition, the use of a rejection filter for the wavelength range of the excitation light source is possible. This filter is arranged on the light outlet side. In an ideal way, it is also a dielectric mirror which throws back the light of the excitation source and, subsequently, additionally improves the luminous efficiency.

In Fig. 3 and Fig. 4, this filter can be directly integrated into the display element. In Fig. 1 and Fig. 2, sufficient clearance from the display element must be upheld in order to ensure the injection-coupling of the excitation light.

The invention is not limited to the embodiments shown here. Moreover, it is possible to realise further embodiment variants by means of combination and modification of the means and characteristics stated herein, without departing from the framework of the invention.

## Reference Numbers List

| | |
|---|---|
| 1 | Substrate |
| 1a | Transparent substrate |
| 2 | Transparent conductive contact with high electron outlet work |
| 2a | Reflective conductive contact with high electron outlet work |
| 3 | Hole transport layer |
| 4 | Emitter layer |
| 5 | Transparent contact with low electron outlet work |
| 5a | Reflective contact with low electron outlet work |
| 6 | Red sub-pixel |
| 7 | Green sub-pixel |
| 8 | Blue sub-pixel |
| 9 | Excitation light source |
| 10 | Projection optic unit |
| 11 | Direction to the projection screen |
| 12 | Dielectric mirror |

## Patent Claims

1. Projection display on the basis of organic light-emitting elements, **w h e r e i n** the organic light-emitting materials are excitatably arranged between two electrodes to a photo luminescence emission and that, by way of these electrodes, an electric field for controlling the photo luminescence quenching effect can be applied.

2. Projection display according to Claim 1, **w h e r e i n** the organic light-emitting elements are switchable both in the emissive mode for conversion of signal voltages into electromagnetic waves as well as in the re-emissive mode for the suppression of a photo luminescence emission (so-called field quenching photo luminescence emission device).

3. Projection display according to Claim 1 or 2, **w h e r e i n** this has an array of organic light-emitting elements which can emit light of different wavelengths.

4. Projection display according to Claims 1 to 3, **w h e r e i n** the organic light-emitting materials are, on the one hand, low-molecular organic emitter materials or, on the other hand, are light-emitting polymer materials, where the light-emitting polymer materials specially originate from the material classes of the polyphenylene vinylene and the polyfluorene.

5. Projection display according to Claims 1 to 4, **w h e r e i n** the light-emitting elements additionally have a hole transport layer which consists of dispersions of poly(ethylene dioxy thiophene) / polystyrene sulfone acid and polyaniline.

6. Projection display according to Claims 1 to 5, **wherein** lamps with a high quota of blue and ultraviolet light such as mercury lamps and/or xenon lamps are used as an excitation source.

7. Projection display according to Claims 1 to 6, **wherein** the voltage for the electric field is applied by way of a driver circuit which is a thin film transistor circuit consisting of polycrystalline or monocrystalline silicon.

8. Projection display according to Claims 1 to 7, **wherein** the emitted light is imaged by way of a projection optic unit onto a projection screen or a diffusing screen.

9. Projection display according to Claims 1 to 8, **wherein** the light-emitting organic elements are arranged on a substrate, where the substrate consists of monocrystalline silicon.

10. Projection display according to Claims 1 to 9, **wherein** the cathode consists of calcium or magnesium or barium or aluminium and can contain additional auxiliary layers made from metal fluorides such as lithium fluoride, barium fluoride or magnesium fluoride.

11. Projection display according to Claims 1 to 10, **wherein** this has in addition a dielectric mirror which is a narrow band mirror for the wavelength range of the emitted light of the organic light-emitting materials.

12. Projection display according to Claims 1 to 11, **w h e r e i n** the dielectric mirror consists of multi-layers with a greatly differing refractive number, where silicon dioxide, silicon nitride or magnesium fluoride are used for low refractive numbers and titanium dioxide, tin oxide, zirconium oxide or tantalic oxide are used for high refractive numbers.

13. Projection display according to Claims 1 to 12, **w h e r e i n** this has in addition devices for the improvement of injection-coupling and de-coupling of the light such as micro lenses and/or reflection-reducing layers.

14. Projection display according to Claims 1 to 13, **w h e r e i n** this has in addition a rejection filter for the wavelength of the excitation light source.

15. Method for the projection by means of modulation and optic imaging of an excitation light source, which comprises the following steps:

   – Excitation of organic light-emitting materials to a photo luminescence emission,

   – Simultaneous control of the photo luminescence emission by means of photo luminescence quenching by the generation of an electric field in the organic light-emitting materials,

   – Imaging of the emitted light.

16. Method according to Claim 15, **w h e r e i n** the organic light-emitting materials are, on the one hand, low-molecular organic emitter materials or, on the other hand, are light-emitting polymer materials, where the light-emitting polymer materials specially originate from the material classes of the polyphenylene vinylene and the polyfluorene.

17. Method according to Claims 15 or 16, **w h e r e i n** the voltage for the electric field is applied by way of a driver circuit which is a transistor circuit made of polycrystalline or moncrystalline silicon.

18. Method according to Claims 15 to 17, **w h e r e i n** the emitted light is imaged by way of a projection optic unit onto a projection screen or a diffusing screen.

## Summary

The invention concerns a projection display on the basis of organic light-emitting diodes and a method for the projection of images and similar.

Where the display according to the invention is concerned, the display elements on the basis of organic light-emitting diodes are used as active control elements. The light-emitting diodes are operated here in the photo luminescence quenching mode.

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Fig. 1

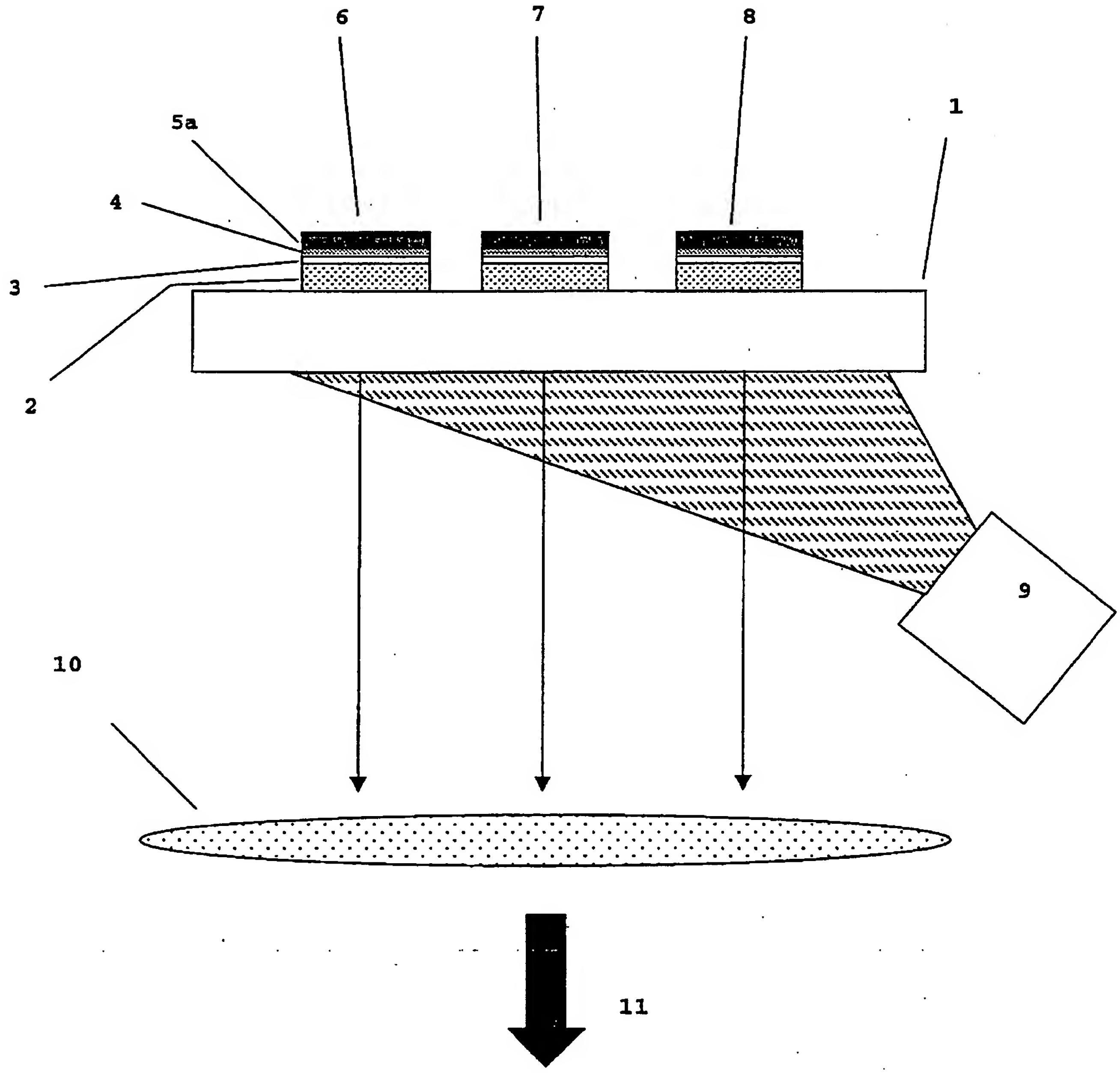

Fig. 2

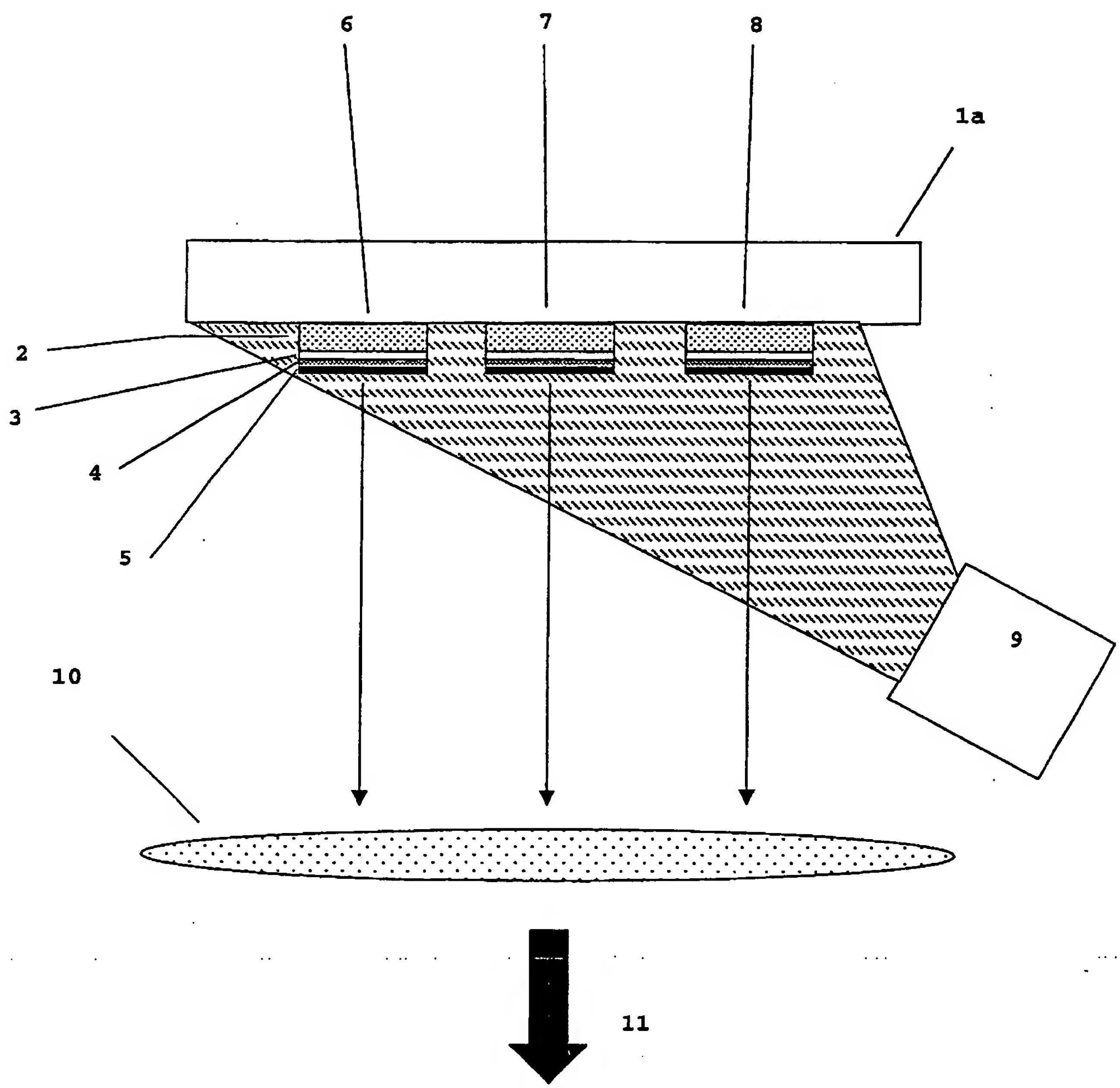

Fig. 3

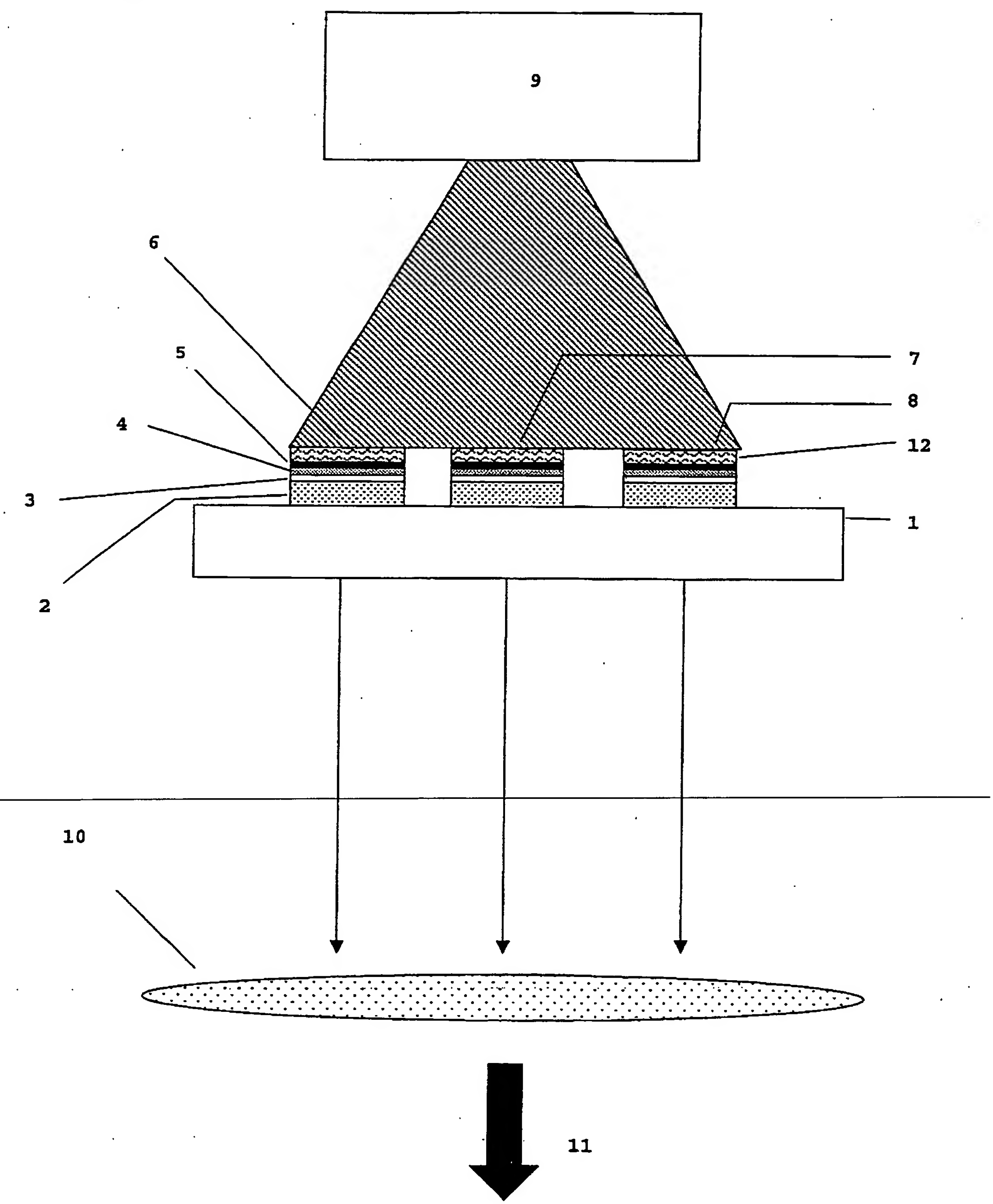

Fig. 4